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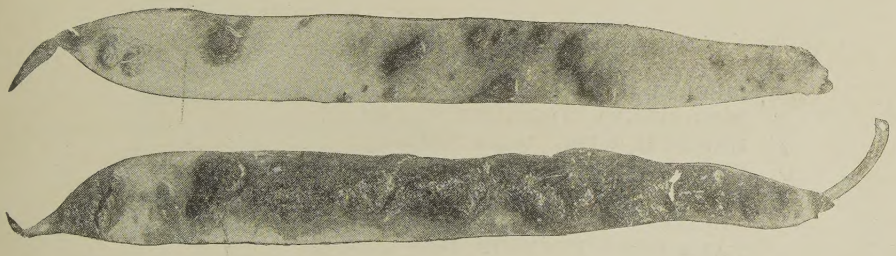
CORNELL UNIVERSITY
AGRICULTURAL EXPERIMENT STATION OF
THE COLLEGE OF AGRICULTURE
Botanical Department (Extension Work)

SOME DISEASES OF BEANS



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13 JUL 1921
OF MYCOLOGY

By H. H. WHETZEL

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COLLEGE OF AGRICULTURE CORNELL UNIVERSITY,
ITHACA, N. Y.

HON. CHARLES A. WIETING,
Commissioner of Agriculture, Albany.

Sir:—For several years, serious diseases have threatened the great bean industry of New York. These diseases are not yet throughly understood, but enough is known about them to warrant the preparation of a brief popular bulletin of advice. It is hoped that this bulletin will call out the expressions of bean-growers who have had experience that will be useful to others; and this Experiment Station will continue its investigations.

Following is an outline of the subjects treated in this bulletin:

General Discussion
How to determine what disease is attacking the beans

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- Nature of the disease
- The disease on the seedlings
- The disease on the leaves and stems
- The disease on the pods
- The disease in the seed

Treatment:
- Seed treatment
- Selection of clean seed
- Removal of diseased seedlings
- Spraying with Bordeaux mixture
- Removal and destruction of diseased pods and stalks
- Cultivating or working in the beans when wet
- Susceptibility of varieties

II. BEAN BLIGHT, page 210
- Nature of the disease
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- The disease in the seed

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- Selection of clean seed
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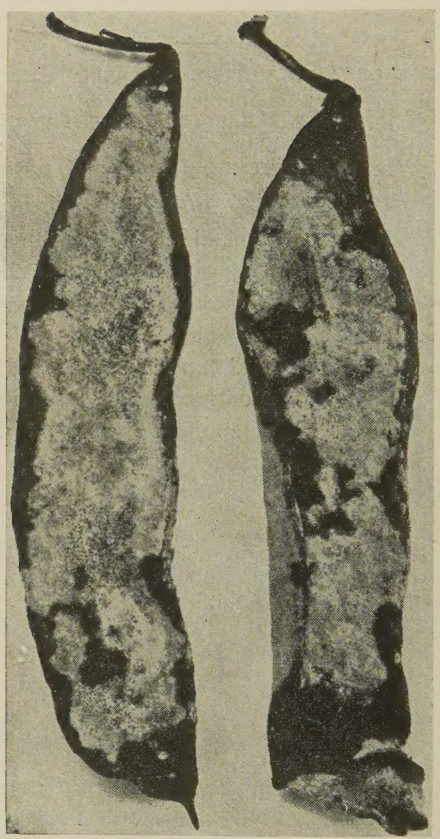
Respectfully submitted,

L. H. BAILEY,
Director.



Mildew on Lima Beans. This disease has not yet been reported in New York but may appear at any time. It is not described in this bulletin, but the picture is placed here in order to call attention to the disease. We desire reports of its presence, in case it is found. The disease attacks only Lima beans. It produces on the pods a covering of white mildew or mold.

Acknowledgments.—This bulletin is largely compiled from information contained in Experiment Station bulletins. Three have been especially valuable. They are:

New York (Geneva) Experiment Station Bull. No. 48, 1892, by Professor S. A. Beach, on "Some Bean Diseases" (Now out of print); New Jersey State Experiment Station Bulletin No. 151, 1901, by Dr. B. D. Halsted, on "Bean Diseases and Their Remedies;" and Ontario Agricultural College Bulletin No. 136, 1904, by Dr. F. C. Harrison and Professor B. Barlow, on "Some Bacterial Diseases of Plants Prevalent in Ontario."

SOME DISEASES OF BEANS.

General Discussion.

Three diseases occur commonly on beans in the state of New York. Named in the order of their abundance and destructiveness, they are: Anthracnose, or "Pod-Spot"; Blight, a bacterial disease; Rust. These diseases are commonly confused by growers. The term "rust" is in many localities applied

Fig. 100.—*Anthracnose or "Pod Spot" of bean.*

to the anthracnose or "pod-spot," probably from the fact that the diseased spots are often of a rusty brown color. In other sections the word "blight" is used to indicate any disease of beans. This confusion of names is very unfortunate, since it leads to the common conception that these troubles are due to the same cause. The three diseases named above are each caused by distinctly different parasitic plants. The life history of these parasites,—i.e. their method of reproduction, of entrance into the bean plant and the means

by which they are carried over from one season to the next,—differs in many respects. In order to combat them successfully it is necessary that the grower have some idea of these differences or at least that he apply the correct name so that he may intelligently consult bulletins or books dealing with these maladies. As the first step, then, determine which disease is causing

FIG. 101.—*Showing anthracnose spots on stem and leaves of bean just before blossoming time. It is from these spots that spores are distributed to the pods.*

the trouble in your beans. The following key will, I think, enable you to determine this with considerable certainty:

How to determine which disease is in your beans.—With some of the diseased beans before you, carefully read the following and compare the specimens with the pictures.

1. Rusty brown or black spots on stems, pods or leaves. Frequently on all (See Fig. 100 and 101). These spots occur on the seed leaves of plants just up (Fig. 103). On the leaves of older plants they blacken and kill the veins on the underside (Fig. 101). Diseased seeds show reddish brown or black

spots and are often shrunken or shriveled (Fig. 104). This disease is the *Anthracnose*. (See page 202.)

2. Leaves at first with large watery brown patches which shortly become dry and brittle (Fig. 109). The diseased leaves curl more or less and look as though they had been scorched. Affected pods show "watery" spots

FIG. 102.—*Anthracnosed bean plants. The disease has eaten off the leaf stalks. From New Jersey Bull. No. 151.*

(Figs. 110 and 111) which do not become black as in the case of anthracnose. Entire pod may become soft and rotten. This disease is the *Blight*, see page 210.

3. Leaves usually remaining green or in severe cases becoming of a sickly yellowish color. Spots on the underside of the leaf very small, rusty brown or black. Sometimes showing on the upper surface of the leaf as black spots with yellow borders (Fig. 113); seldom occurring on the stems or pods. This is the true *Rust*, see page 213.

If after having carefully studied this key and the photographs, you are not

satisfied which disease you have on your beans, send some of the affected plants to the Plant Pathologist, Cornell University Experiment Station, Ithaca, N.Y. He will be glad to make an examination and report to you. Having determined which disease is giving you trouble, turn to the page indicated and carefully read the description and treatment for that disease. You will frequently find both the anthracnose and the blight on the same plant, and sometimes even the rust also.

I. BEAN ANTHRACNOSE.

FIG. 103.—*Bean seedling, showing the anthracnose spots on stem or seed-leaves (After Halsted).*

The anthracnose is at present the most common and destructive disease of beans in this State. It is very probably the disease that is destroying your crop. Its most apparent injury is on the pods, where it forms large dark rusty brown or black spots. (See cover.) It is on this account frequently known as "pod spot". The disease may and usually does occur, however, on all parts of the plant except the roots. (Fig. 101). It is caused by a fungus known to botanists as (*Colletotrichum lindemuthianum*) which lives as a parasite in the tissues of the bean. This fungus is a plant, as much a plant as the bean on which it lives. It has a thread-like mycelium that grows into the the tissue of the bean to obtain food for its growth and development and it produces *spores* that serve the purpose of seeds by which it spreads to healthy beans and so reproduces itself. In fighting the anthracnose fungus, we are fighting a parasitic weed, in its habits not greatly unlike the dodder which often destroys alfalfa.

The fungus itself is too minute to be seen by the unaided eye. This makes an understanding of its nature and ways of life rather difficult, but the picture of the parasite as shown in Fig. 105 will help to make clear the discussion of the disease. Study the picture carefully before reading the following account.

The disease on seedlings.—The disease makes its first appearance on the bean seedlings, as they come up. It may then be detected, on at least some of the young plants, as brown discolored sunken spots or cankers on the seed-leaves or the stem (Fig. 103). This early appearance of the disease is due to the fact that the fungus is usually carried over winter in the seed and so is already in the bean when it is planted. This is fully explained later. (Page 205.) In severe cases the spots or cankers may be so numerous as to cause heavy loss in the seedlings and result in a poor stand. Sometimes the stem is so badly diseased or "eaten" near the base that it falls over and dies. Usually so few of the seedlings are attacked that the presence of the disease in a field is at first overlooked. Nevertheless, as the season advances the

fungus spreads to healthy plants near by, by means of its multitude of tiny spores produced in these spots on the seedling and before the grower knows it his entire field may be badly affected.

The disease on leaves and stems.—From the spots on stem and seed-leaves of the seedlings the spores find their way to the large leaves and branches of the rapidly growing plants (Fig. 101). The large veins of the leaf are frequently eaten through and killed by the fungus, and holes or cracks with blackened margins appear in the blade. While this may not entirely kill the leaf, it greatly lessens its efficiency as a starch maker and so indirectly but effectively reduces the yield of seed. Many times, however, the attack is so severe that the leaf stems are cut off and the entire plant is practically ruined (Fig. 102).

FIG. 104.—*Beans badly affected with anthracnose. Such seed should never be planted.*

The disease on pods.—It is from the attack of the disease on the pods that the most direct and apparent damage to the crop results. During the time of blossoming and previous, the fungus has been spreading and becoming established on the stems and leaves, and it now attacks the young and succulent pods. With their tender growing tissue full of water and food materials, these pods offer the best conditions for the growth and development of the parasite. Spores from the spots on the leaves and stems fall on the pods where, in the presence of moisture and the high summer temperature, they germinate, forming a little sprout or germ-tube, which penetrates the tender skin of the pod (Fig. 105) and, branching in the juicy tissues, gives rise to an anthracnose canker. These first appear as little brown or rusty spots which enlarge and darken until nearly or quite black. The dead tissue dries

and settles, causing a little pit or sunken place in the pod. In the center of the spot the spores of the fungus are now produced in great abundance. They ooze out and pile up, forming little pink masses easily seen with the naked eye (see diseased pods on cover). These masses of spores are held together by a kind of glue or mucilage which, when dry, sticks them tightly to the spot. When a drop of rain or dew falls on the spot the mucilage is at once dissolved, and the spores are set free in the water. At this

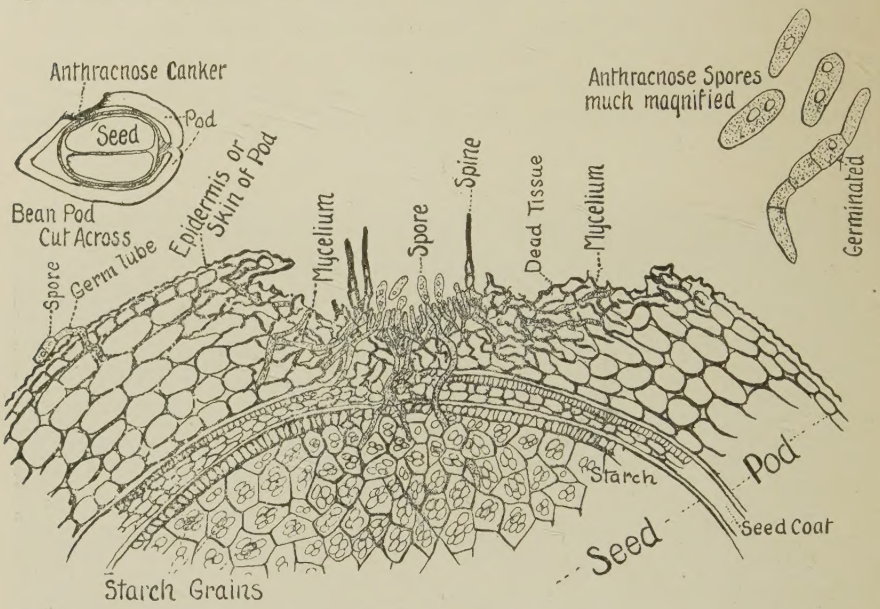


FIG. 105.—*Showing the relation of the anthracnose fungus to the tissues of the bean. To the left above is a diagram of a section across a bean pod through an anthracnose canker. The large drawing below is a much enlarged view of a portion of this same section. It is largely diagramatic. It shows how the mycelial threads of the fungus may penetrate the seed coat and enter the starchy tissue of the seed, there to remain dormant until the following season. On the left of the large drawing is shown a spore germinating and penetrating the epidermis. This germ tube branches, spreads through the tissues of the pod and so gives rise to a new spot or canker. To the right above is shown a magnified view of some of the spores of the anthracnose fungus. One has germinated.* (*Original.*)

time any disturbance of the bean plants will scatter these spores in the flying drops of water. In this way they reach healthy plants near by. This explains why beans should not be cultivated or handled in the early morning while the dew is still on them or directly after a shower. The spores of the anthracnose fungus are scattered only when they are wet. This will also explain why a warm rainy season is so favorable to the development of the fungus. The spores require moisture in which to be distributed and in which to germinate. A relatively high temperature is also most favorable to the disease. The spores are produced in unlimited numbers in the spots on the pod. Fig. 106

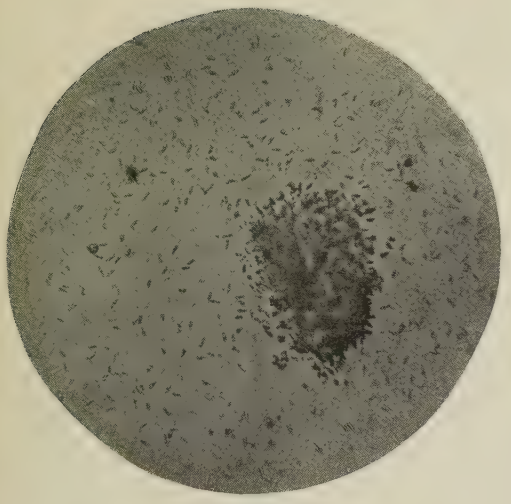


FIG. 106.—*Spores of the anthracnose fungus taken on the point of a needle and placed in a drop of water. Magnified about 55 times. The large blur is a mass of the spores from which others have become detached and scattered about in the water.*

shows the spores taken on the point of a pin and placed in a drop of water. Only one of these tiny spores is necessary to start a spot. Under favorable conditions these spores spread from pod to pod until practically every bean in a large field may be effected. Sometimes "string beans" that appear to be perfectly clean and free from the disease will become very badly spotted if left in boxes or bags for a short time. This frequently occurs during shipment to market. In such cases the beans are either infected before or during picking or become contaminated from a few spotted pods that have been overlooked and put into the bags with the clean beans. *No spots will appear on the leaves, stems or pods unless spores find their way to these parts of the plant.* The spores may be scattered by the cultivator, the pickers, by animals, or by the wind in damp or rainy weather.

The disease on the seed.—As the threads or mycelium of the fungus penetrate deeper into the pod they finally reach the seed within (Fig. 105). In the unripe condition the seed-coat is easily penetrated by the mycelium and the fungus is thus established directly in the seed itself. Unless the seed is entirely destroyed by the fungus, it ripens and the enclosed mycelium becomes dormant. The presence of the fungus in the seed may usually be detected by the brown or yellowish discoloration of the seed-coat. When the seeds are badly effected, they become more or less shriveled as well as discolored (Fig. 104). It is thus easy to tell with considerable certainty whether seed to be planted is affected with anthracnose. When the seed is planted in the spring the enclosed but dormant fungus is planted with it. The moisture and warmth which stirs the bean to life awakens the fungus also. In the soft and fleshy seed-leaves in which it is inbedded the mycelium finds an abundance of food and grows rapidly, soon forming a spot or canker and producing spores which at once begin again to spread the disease to neighboring healthy plants.

Treatment of Anthracnose.

Seed treatment.—Soaking the seed in formalin, corrosive sublimate and other poisons, and in hot water, have been tried by different experimenters with

varying results. So far no one has been able to prevent the disease entirely by such treatment. As already pointed out, the fungus mycelium is imbedded in the bean itself. Any poison that will penetrate sufficiently to kill the fungus will usually kill the seed. There are also other objections: that soaked seeds cannot be conveniently handled in the planter and if allowed to dry, many will "slip" their coats; the reduction in "stand" and consequent necessity of planting a larger quantity of seed is also another objection. On the whole, seed treatment cannot yet be recommended. It is a point that needs further experimental investigation.

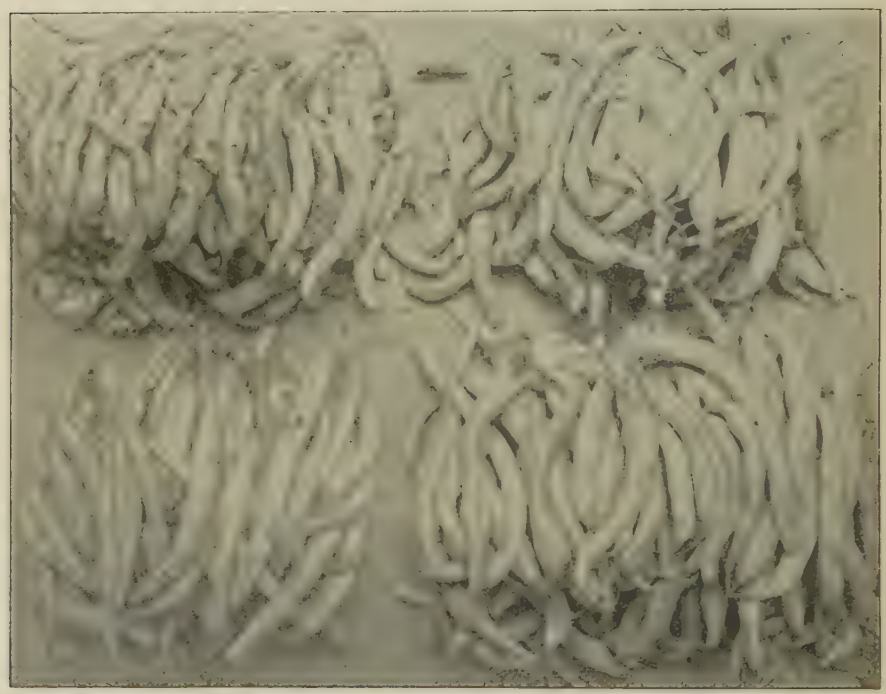


FIG. 107.—*Above unsprayed; below, sprayed once with Bordeaux mixture. The spotted pods are placed at the left in each case.*

Selection of clean seed is of first importance in growing a clean crop. All beans to be planted should be most carefully "hand picked" and all beans showing discolorations, wrinkles or blisters should be discarded. *This cannot be too carefully done.* It has been found that in some cases where 95 per cent of the beans were marketable *only one per cent was fit for seed.*

Removal of diseased seedlings.—As soon as the bean plants are well through the ground, they should be carefully examined and *all diseased seedlings pulled up, carried from the field in a sack, and burned.* This is the

second step in the contest with the anthracnose and it is important, since even the most expert will overlook some of the diseased seeds in sorting.

Spraying with Bordeaux mixture.—As soon as the plants are well up, and the first pair of true leaves begins to unfold, *spray thoroughly with Bordeaux mixture.* Probably the best formula to use is five pounds copper sulfate, four pounds of stone lime to 50 gallons of water. A stronger solution has been found to dwarf the plants, while the weaker solution is equally as effective in preventing the anthracnose. This should be so *thoroughly applied that every part of the plant above ground will be completely covered.*

In about ten days or two week the plants should have a second spraying, using the same strength of mixture. This application should be as thorough

Fig. 108.—*Niagara Gas Sprayer with nozzles especially arranged for spraying beans. Used on the farm of C. N. Keeney, LeRoy, N. Y., during the season of 1905.*

as the first. This is to cover and protect the new growth of leaves and branches.

Unless excessive rains wash the mixture off, it will not be necessary to spray again until the pods are forming, shortly after blossoming time. A third application of the same strength and thoroughness should now be made. The nozzles should be so arranged that the *pods as well as stems and leaves will be thoroughly coated. This is important.* (See Fig. 108).

In most cases three sprayings will be sufficient. If the seed was badly diseased and if the plants show an abundance of the anthracnose, more sprayings will probably be necessary to insure a clean crop. Excessive rains will

also necessitate more frequent applications. The effect of heavy rains in washing off the mixture may be overcome by adding to the Bordeaux mixture the following: two pounds resin, one pound sal soda, one gallon of water. Boil together until of a clear brown color. Add one-half this amount to each barrel of the Bordeaux. An extra spraying between the second and third, and another after the third when the pods are nearly full grown, will no doubt

FIG. 109.—*"Blight" on bean leaflet. From New Jersey Bull. No. 151.*

be sufficient in the worst cases. That this disease is easily controlled by the Bordeaux mixture is shown in Fig. 107. Repeated experiments by the writer have shown that one or two thorough sprayings even after a large percentage of the plants are badly diseased will insure a comparatively clean and profitable crop. A single spraying done under the direction of Professor Craig in a field of Mr. C. N. Keeney near LeRoy, N. Y., reduced the anthracnose twenty per cent.

The removal and destruction of diseased pods and stalks is also a matter not to be overlooked. While the disease is most commonly carried over in the seed, it has also been demonstrated that diseased pods and stems thrown on the fields in which beans are to be planted will result in a marked increase of the disease the next season. For this reason all diseased pods and stalks should be burned, or, if they go into the manure pile, the manure should not be put on fields in which beans are to be planted.

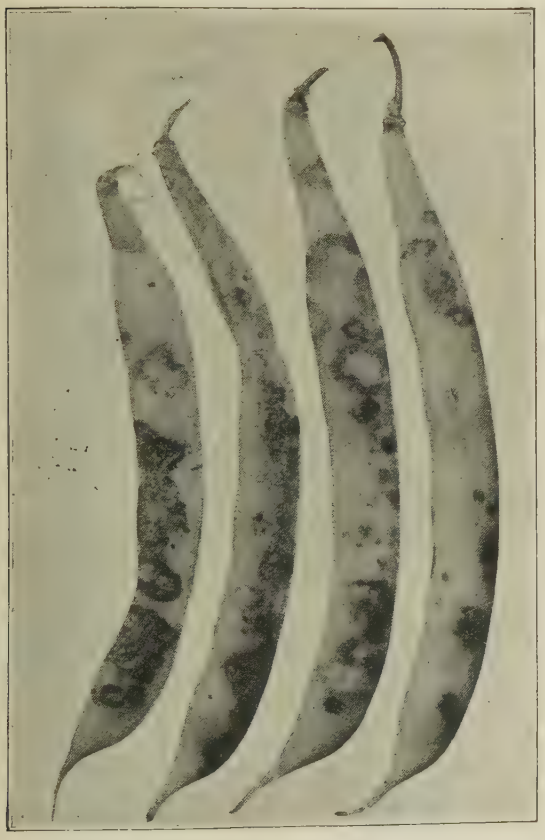


FIG. 110.—"*Blight*" *on pods of Wax beans. From New Jersey Bulletin No. 151.*

Cultivating or working in the beans when wet should be avoided as much as possible. As already pointed out, the spores of the disease are disseminated only when in drops of rain or dew. When dry the mucilage in which they are enclosed fastens them to the spot and they cannot be scattered. For the same reason "string" or "snap" beans should not be picked when wet. The handling of a single spotted pod may be sufficient to spread the disease throughout an entire row, or spot all the pods gathered. Repeated cropping of the same land with beans is not desirable and, fortunately, not commonly practiced.

Susceptibility of varieties.—It is well known that certain varieties are more susceptible than others to this disease. This is notably true of the common "Wax" varieties. So far as the writer has been able to discover, no very extensive information on this point is to be had. Numerous "Rust Proof" varieties have been placed on the market, but while some of them are more or less resistant probably all will spot under conditions most favorable to the fungus. Dependence, therefore, should not be placed on the resistance ability of any variety. *All should be thoroughly sprayed if immunity to the disease*

is to be expected. No record has been discovered of anthracnose on Lima Beans.

II. BEAN BLIGHT

The blight is a bacterial disease. It is caused by a minute parasitic plant (*Bacterium phaseoli*) in form and habits of life quite unlike the anthracnose fungus. These tiny bacteria have no mycelial threads and no spores. Each little cell (Fig. 112) is a plant in itself. The bacteria increase in numbers by each one simply dividing into two which, when full grown repeat the process. Each one is supplied with a long fine *flagellum* or tail by which it may wiggle about to some extent in the tissues of the bean.

The blight attacks the ordinary field and garden varieties and also the Lima Beans. It was first observed in this State by Professor Beach of the State Experiment Station in 1892. Like the anthracnose, it attacks all parts of the bean above ground but is most conspicuous on the foliage and pods.

FIG. 111.—"*Blight*" *on pods of Lima beans. From New Jersey Bulletin No. 151.*

The disease on leaves.—The first evidence of the blight is usually to be observed in the leaves. These show large brown dead patches (Fig. 109), often spreading through the entire leaf. When wet, the spot is soft and watery but when dry, becomes papery and brittle. On a badly blighted patch the leaves become dry and curled, as if scorched. The bacteria probably always enter the bean plant through a wound. Judging from some observations made last season, it seems likely that certain insects are in most cases the agents by which this disease is carried from plant to plant. This is an important point in the life history of the parasite and one that requires further observation

before definite statements can be made. Having gained entrance to the leaf, the disease gradually travels down the stem to other leaves and to the pods. Professor Barlow of the Ontario Agricultural College, has shown that the progress of the disease is comparatively slow. Leaves of beans inoculated with the bacteria did not show symptoms of the disease until the third week. The bacteria increase in such numbers that finally they may fill up the sap tubes in the stem, cutting off the water supply and so cause the entire plant to wilt and die.

The disease in the pods.—Through wounds or by way of the stem the bacteria find their way into the pods which, if young, may shrivel and die. In the larger pods they produce spreading watery spots (Fig. 110 and 111) which finally become more or less discolored but never sunken and black as in the case of the anthracnose.

The disease in the seed.—From the pod the disease readily gains entrance to the growing seeds. The pods are not destroyed unless attacked when very young, and when ripe they may show considerable discoloration or none at all. The bacteria, however, have gained entrance into the seed, as in the case of the anthracnose, remain there dormant throughout the winter. With the germination of the seed in the spring the bacteria also begin to multiply and find their way to healthy beans and so the infection spreads.

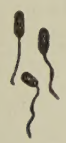


FIG. 112.—*Bacteria that cause the bean blight much magnified. (After Smith).*

Treatment of Blight

Seed treatment.—No method of treating the seed to prevent the blight has yet been proposed and properly tested. Professor Barlow has demonstrated that the bacteria are readily killed by exposure for ten minutes to water heated to 122°F., while dry beans can endure such a temperature for some time without injury While this gives some

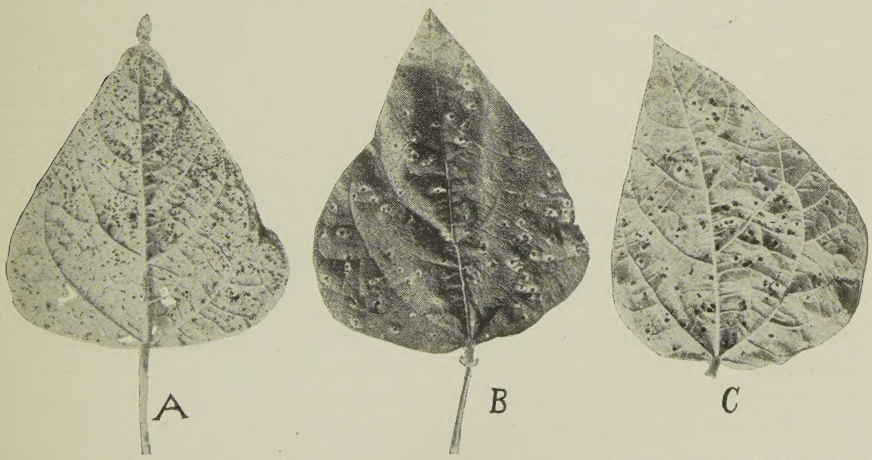


FIG. 113.—*Bean Rust. A. Summer spores on underside of leaf. B. and C. Winter spore. Note the light border around the spots on the upper side of the leaf B.*

promise of success the treatment is open to many of the objections raised in the case of the anthracnose (see page 206)

Selection of clean seed.—The sorting of seed effected with anthracnose has been shown to be highly desirable. Its value in the case of seed effected with blight is very questionable Owing to the fact that blight-effected seeds are often not discolored, it is manifestly impossible to sort them from the healthy ones. The safest method is to discard all seed known to have come from fields that showed the disease.

Destruction of diseased tops; rotation.—In regard to these practices Professor Barlow says, "A field where beans have sickened with this disease is unfit for growing beans for at least one season, as the germ lives over at least one winter in the stems and leaves left on the ground. How long such a field may remain infected is unknown, for we do not yet know whether the germ can live and increase in the soil where no beans are growing, although this is probable. Bean straw from infected fields may be burned. If it is fed to animals or used in bedding, the manure should be returned to the field on which the beans grew, and not spread on fields as yet free from the disease."

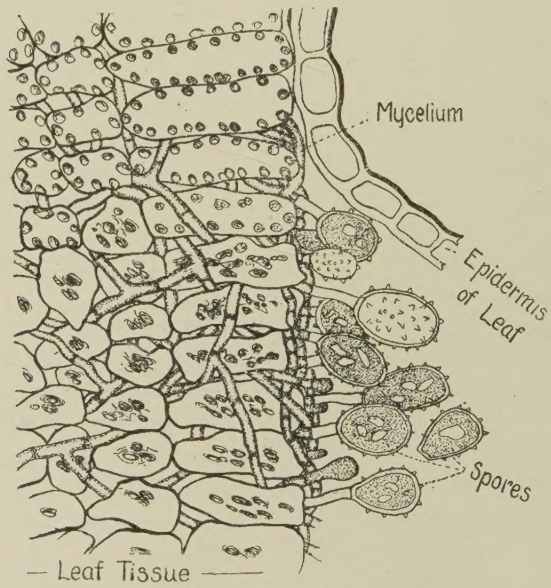


FIG. 114.—*Diagramatic section across a bean leaf effected with "summer stage" of the "Rust." The spores are formed on the ends of the mycelial threads, just beneath the epidermis which is pushed up and broken. The light brown summer spores are thin-walled and warted. The mycelium grows through the leaf tissues between the cells which become shrunken and distorted, and so unable to do their work properly.*

Spraying.—At the New Jersey Experiment Station, Dr. Halsted has experimented for a number of years with several spray mixtures for the prevention of bean blight. The Bordeaux mixture of the strength recommended for the anthracnose has been found to be very satisfactory. Probably a larger number of applications will be necessary for the blight than for the anthracnose.

III. BEAN RUST

The true rust of beans is, like the anthracnose, a fungous disease. It differs from the anthracnose, however, in many important respects. The most important difference from the grower's point of view is that it is a much less common and destructive disease. It occurs only on the leaves of the bean, rarely on the stems and pods. Except in very severe cases, it does not materially injure the leaves.

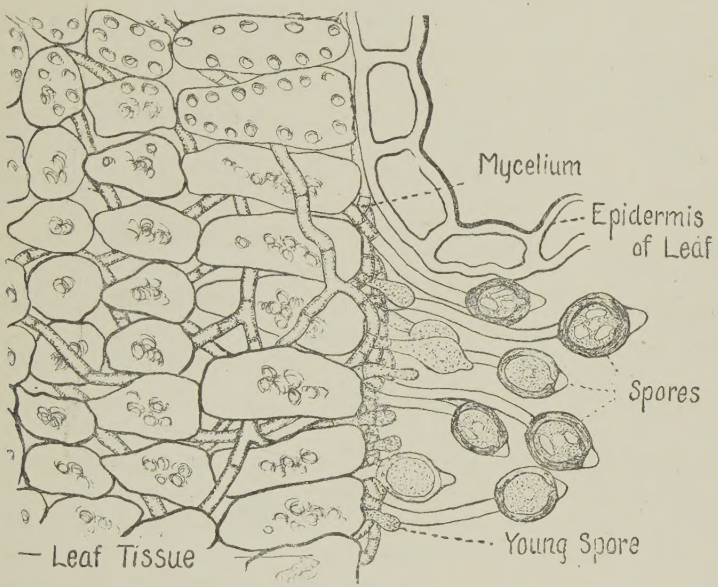


Fig. 115.—*Diagramatic section through a bean leaf effected with "winter stage" of the "Rust." The spores are formed like the summer spores on the ends of mycelial threads just beneath the epidermis. The spores are however smooth and very dark brown or nearly black. Their walls are thick and their contents oily which enables them to withstand much cold and drying.*

The rust fungus (*Uromyces appendiculatus*) sends its mycelial threads into the tissues of the bean leaf there to secure nourishment for its own growth and development. From the ends of the threads that come to the surface at certain spots, spores are formed (Fig. 114). These are of two kinds; the summer-spores, brown and forming powdery specks (Fig. 113A) on the underside of the leaf which readily rub off on the hands as a rusty brown powder; the winter spores, black and produced in small compact warts on the underside of the leaf or sometimes also on the upperside (Fig. 113B and C). The spots on the upper side are commonly surrounded by a yellow border. The summer spores appear rather early in the season and are produced in abundance. It is by means of these spores that the disease is spread. The black winter-spores (Fig. 115) appear later. They result from the late infections

by the summer spores. The mycelium never spreads far from the point of infection and, unless these points are numerous, but little damage is done to the leaf. The disease winters in the old leaves.

Treatment of Rust.

While this disease is not common and is rarely destructive, yet it is desirable that it should not become well established on a farm. Under very favorable conditions it might become sufficiently abundant materially to injure the crop. Therefore, it is well to learn to know it and so be able to stamp it out whenever it appears. Since the disease winters only in the diseased tops, it is readily exterminated by burning all diseased plants after the beans are harvested. When beans are sprayed for anthracnose this disease will also be controlled.

IV. APPARATUS FOR SPRAYING BEANS

Any sprayer that will *thoroughly cover every part of the plant* with the Bordeaux mixture may be used. It is not possible to recommend any one machine as the best for spraying beans. The kind of power used is immaterial so far as effectiveness is concerned, provided it gives sufficient pressure. The grower must decide for himself what power will be most desirable in his case. The important thing aside from the pressure is the arrangement of nozzles. Fig. 109 shows an arrangement of nozzles which are said to be very satisfactory. Below is given a list of spraying machine manufacturers who furnish with their machines nozzle arrangements for spraying beans (probably others will also furnish them):

Niagara Sprayer Company, Middleport, N. Y. Liquified Carbonic Gas.

The E. C. Brown Company, Rochester, N. Y. Compressed air, compressed by power from the axle.

The Gould's Manufacturing Company, Seneca Falls, N. Y. Hand power or Gasoline engine.

The Standard Harrow Company, Utica, N. Y.

Field Force Pump Co., Elmira, N. Y.

Bateman Manufacturing Co., Grenloch, N. J.